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D30 HVAC

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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	06/28/99	Document rewritten and reformatted to support LIR 220-03-01, FEM. Superseded Mechanical Facilities Engineering Standards, Volume 6, Manual Revision No. 15, dated 6/26/98.	Danny Nguyen, <i>PM-2</i>	Dennis McLain, <i>FWO-FE</i>
1	05/22/02	General revision, split into Unifomat-based sections, added endnotes. This LEM section replaced FEM Subsections 204.2-.6, 204.20-.21, and 204.25. Added pump requirements.	Tobin H. Oruch, <i>FWO-SEM</i>	Kurt Beckman, <i>FWO-SEM</i>
2	6/9/04	Combined D30GEN with D30 HVAC. Added full 1993 climate data. Modified requirements: general and hood altitude correction, eyewash requirements for chemical treatment stations, coil requirements, use of de-ionized water for humidification, motor selection for fans. Made table of standards broadly applicable; changed LEM to ESM. Gave POC authority on low NOx waivers. Added requirements on direct-fired heater, 2-way valves, steam constants, mech room heat, boiler types and control, relief air dampers, duct lining, independent TAB. Improved guidance on ceiling plenums, etc.	Charles DuPrè, <i>FWO-DECS</i>	Gurinder Grewal, <i>FWO-DO</i>

RESPONSIBLE ENGINEERING STANDARDS POC AND COMMITTEE

for upkeep, interpretation, and variance issues

Ch. 6, D20	<u>Mechanical POC/Committee</u>
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D30GEN ADDITIONAL GENERAL HVAC REQUIREMENTS

Note: Refer to the Mechanical Chapter section D10-30GEN for general mechanical and HVAC requirements. General and HVAC piping requirements are in section D20, Plumbing/Piping/Vessels (e.g., cross connection and expansion control, freeze protection, etc.).

1.0 CODES AND STANDARDS

- A. Comply with the following Codes and Standards as well as others listed in D10-30GEN and other applicable ESM sections.

1.1 ACGIH (American Conference of Governmental Industrial Hygienists)

- A. Industrial Ventilation Manual.¹
- B. *Guidance: American Industrial Hygiene Association AIHA Z9.5, Laboratory Ventilation.*

NOTE: Many national standards that follow are available for LANL at <http://lib-www.lanl.gov/infores/stand/stanihs.htm>

1.2 ARI (Air-Conditioning and Refrigeration Institute)

- A. <http://ari.org/std/standards.html>

1.3 ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers)

- A. HVAC Handbooks.¹
- B. Standard 15, Safety Code for Mechanical Refrigeration.¹
- C. Standard 55, Thermal Environmental Conditions for Human Occupancy.
- D. Standard 62, Ventilation for Acceptable Indoor Quality (1999 until changed by WSS).²
- E. Standard 90.1, Energy Standards for Buildings Except for Low Rise Residential Buildings.³

¹ Nationally recognized standards. Also, when systems exceed the temperature and pressure ratings of the UMC or UPC, nationally recognized standards are used per 1997 IAPMO UMC, Section 1201.1 on hydronic piping.

² WSS Mechanical Focus Team voted to invoke the noted edition per meeting 1/23/02 minutes (EMref-1) (**Note:** EMref refers to a Standards Program filing system for hard-to-find references.)

³ ASHRAE Standard 90.1 was developed as a result of an ASHRAE and DOE jointly formed committee (Special Project 41) and it complies with the mandatory energy conservation performance criteria standards for federal buildings (10CFR435). Also, the Federal Energy Policy Act of 1992 requires States to adopt ASHRAE Standard 90.1. Compliance meets LEED Rating System (prerequisite), Energy and Atmosphere-Minimum Energy Performance.

1.4 NFPA (National Fire Protection Association)

- A. National Fire Codes and Standards (all except NFPA 5000; NFPA 70 National Electrical code edition as stated in WSS).
- B. Buildings and structures designed to fully meet the requirements of NFPA-101, The Life Safety Code, shall be considered to have met the “life safety” requirements of UBC, OSHA (29 CFR 1910), and all other codes.⁴
- C. *Listing of current NFPA codes and standards are also available at:*
<http://www.nfpa.org/catalog/>

1.5 SMACNA (Sheet Metal and Air Conditioning Contractors National Association)

- A. HVAC Duct Construction Standards, Metal and Flexible.¹
- B. HVAC Systems, Duct Design.¹
- C. Seismic Restraint Manual, Guideline for Mechanical Systems¹
- D. Rectangular Industrial Duct Construction Standards.¹
- E. Round Industrial Duct Construction Standards.¹
- F. *Guidance: Guide for Steel Stack Construction.*
- G. *Guidance: Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.*

2.0 ALTITUDE/CLIMATIC CRITERIA AND HEAT GAIN EQUATIONS

- A. See Chapter 1 Section Z10 for altitude, latitude, barometric pressure, air density, and air density ratio values.
- B. Heating Degree-Days (annual mean): 6219 at 65 degrees F base; 2680 at 50 degrees F base.⁵
- C. Cooling Degree-Days (annual mean): 2187 at 50 degrees F base, 272 at 65 degrees F base⁵
- D. Correct Q for altitude. *Values for 7500 feet (suitable for many locations/situations) are:*
 - 1. $Q \text{ (sensible heat)(Btu/hr)} = 0.82 \text{ (@ } W = 0) \times \text{cfm} \times \Delta t \text{ (at sea level 0.82 would be 1.08)}$ ⁶
 - 2. $Q \text{ (latent heat)(Btu/hr)} = 0.52 \times \text{cfm} \times \Delta W \text{ (gr.) (at sea level 0.52 would be 0.68)}$ ⁶
 - 3. $Q \text{ (total heat)(Btu/hr)} = 3.42 \times \text{cfm} \times \Delta h \text{ (at sea level 3.42 would be 4.50).}$ ⁶

⁴ LIR 402-910-01, LANL Fire Protection Program.

⁵ FWO Calculation No. 00-0000-CALC-M-000 _____

⁶ Sea level constants 1.08, 0.68, and 4.50, and equations are from 2001 ASHRAE Fundamentals Handbook, pages 29.18 and 29.19. Constants have been corrected for 7500 foot conditions.

Where:

cfm = Air flow Rate, cubic feet/min.

ΔW (gr) = Humidity Ratio Difference, gr. water/lb. dry air.

Δh = Enthalpy Difference, Btu/lb. dry air.

W = Humidity Ratio, lb. water/lb. dry air.

Δt = Temperature Difference, degrees F.

- E. Use Table D30GEN-1 local climate information for HVAC system sizing/design. *It is presented in the format of the 1993 ASHRAE Fundamentals Handbook, Load and Energy Calculations Division, Weather Data Chapter 24. Refer to ASHRAE Handbook for explanation of columns and acronyms. [Guidance: 1994-2003 data (both I-P and S-I unit) for energy usage predictions (not sizing) is available from the Mechanical POC or directly from LANL Calculation 00-0000-CALC-M-0006.].*

TABLE D30GEN-1

Climatic Conditions for the United States (from ASHRAE Fundamentals 1993 Weather Data Table 1)

Col. 1	Col. 2		Col. 3		Col. 4	Winter, deg F		Summer, deg F					Prevailing Wind		Temp, deg F		
						Col. 5		Col. 6			Col. 7	Col. 8		Col. 9		Col. 10	
State/Station	Design		Design Dry Bulb and Wet-Bulb					Mean	Design			Median of					
	Lat.	Long.	Elev.	Dry-Bulb		Mean	Coincident	Wet-Bulb	Daily	Wet-Bulb		Winter	Summer	Annual Extr.			
	deg	N	deg	W	Feet	99%	97.5%	1%	2.5%	5%	Range	1%	2.5%	5%	Knots	Max.	Min.
New Mexico																	
Los Alamos	35	52	106	19	7410	5	9	89/60	87/60	85/60	32	62	61	60		89.8	-2.3

3.0 ALTITUDE CORRECTION

- A. *Guidance: At LANL's altitude, the air pressure and density is lower than at sea level, the condition for which HVAC equipment is designed/rated. Therefore, HVAC equipment operating at LANL produces less than its catalog rating. Correcting for this during design is required so that procurement of appropriately larger equipment occurs. Thus, in the procurement spec that's developed after the sizing calculations, this larger equipment should be specified, knowing it will be adequately sized when operating at LANL altitude. The spec should either (1) be clear that output ratings are already adjusted for altitude and should not be further adjusted by the vendor, or (2) leave correction up to the vendor (e.g., "Achieve XXX Btu/hr at 7500 feet"). If the correction has been made and captured in the specification's data, then the procurement spec shouldn't also say something like "equipment provided be sized for LANL altitude," since this could result in a doubly-corrected outcome.*
- B. *Ideally, **only** the calculated actual operating parameters (capacity, static pressure, cooling/heating loads) required at 7500 ft elevation should be shown on the design drawings and in the technical specifications. Only a statement such as "ALL CAPACITIES SHOWN OR INDICATED ARE AT 7500 FT ELEVATION" should be included in the drawings or specifications. It should be the responsibility of the Contractor or the equipment manufacturer to make the needed adjustments to their equipment to meet the requirements at the 7500 ft elevation. The equipment manufacturer should be asked to provide submittal (fan curves, performance data) to back up their selection.*

3.1 Fans

- A. *Correct catalog data before applying it at LANLs 7500 foot altitude. **Guidance:** Failure to correct for altitude will result in undersized equipment. An increase in altitude means a decrease in air density and barometric pressure. Air moving equipment is rated and cataloged at sea level (standard air density 0.075 pcf at 70 degrees and 29.92 inches Hg barometric pressure)*
- B. ***Guidance:** Fans are constant volume devices and therefore air density has no effect on the volume delivered; however, it does affect the motor horsepower, static pressure, and mass flow rate.*

3.2 Fan Selection Procedure at 7500 Foot Altitude (Guidance)

- A. *Determine the actual volumetric flow rate (acfm) at 7500 feet.*
- B. *Using this actual flow rate (acfm) and standard air (sea level) friction data to design the ductwork, calculate the system static pressure at sea level.*
- C. *Select the fan by referring to sea level fan capacity tables and using the actual cfm required at altitude and the system static pressure calculated at sea level. The rpm shown in the tables is the rpm at which the fan must operate and need not be corrected.*

- D. *Correct the static pressure and brake horsepower (bhp) shown in the fan tables to altitude conditions by dividing these values by the air density ratio at 7500 feet (nominal 1.32 at 70 degree F). This yields the static pressure that the fan will produce at altitude and the BHP required at altitude. Refer to Table D30-GEN-2 when installation environment involves non-standard temperatures at 7500 feet elevation.*

TABLE D30GEN-2⁵

Air Density Correction Factor at 7500 Feet Altitude		
<i>Temperature (F)</i>	<i>Density (PCF)</i>	<i>Air Density Ratio</i>
0	0.065	1.15
40	0.060	1.25
55	0.058	1.29
60	0.058	1.30
65	0.057	1.31
70	0.057	1.32 (Nominal)
80	0.055	1.35
85	0.055	1.36
90	0.054	1.37
95	0.054	1.39
100	0.054	1.40
120	0.052	1.45
140	0.050	1.50

- E. *High Temperature: Exercise caution in selecting the motor sizes for operating fans handling high temperature air. If a fan system designed to operate with high temperature air is started when the system is cold, the fan will require more horsepower during start up; therefore, the motor size should be selected for cold starting.*

3.3 Air Conditioning and Refrigeration Equipment, Etc.

- A. Derate air-cooled equipment (e.g., chillers, coils, condensers, cooling towers, VAVs, VFDs) for altitude. *Guidance: Consult with manufacturer and the following publications for derating data:*
1. *Carrier: Engineering Guide for Altitude Effects.*
 2. *Trane: Effects of Altitude on Air Conditioning Equipment.*

3.4 Air Compressors

- A. Derate the compressor air delivered (scfm) rating for altitude and temperature. Consult with the manufacturer for derating criteria.

3.5 Fume Hood and Local Exhaust Design

- A. The exhaust airflow from fume hoods and other local exhaust systems such as welding benches, snorkels, and open surface tanks must be determined carefully. These exhaust airflows shall be based on an equivalent mass basis rather than on a volumetric basis.⁷ Therefore, when calculating the airflow needed, the face or capture velocity required at sea level conditions shall be multiplied by the density ratio.

- B. *Example (guidance):*

Fume hood face velocity is specified to be 100 FPM (at Standard Temperature & Pressure).

Fume hood open face area is 60 in. by 24 in. (Area = 10 ft²)

The density ratio for 7500 ft and 70° F is 1.32 (Table D30GEN-1 above)

Airflow = Area x Velocity

Airflow = 10ft² x 100 FPM x 1.32 = 1320 ACFM

3.6 Gas-Fired Equipment

- A. Determine natural gas consumption (cfh) by dividing the Btu/h input rating at sea level by the gas heating value of 1000 Btu/ft³.⁸
- B. Derate gas-fired heating units and atmospheric boilers catalog output rating by 30 percent.⁹
- C. For forced-draft boilers, consult with manufacturer for derating criteria.

3.7 Motors

- A. Refer to the Motors subsection herein for deration and selection criteria.

4.0 CHEMICAL WATER TREATMENT

- A. Clean, flush, and chemically-treat process water in HVAC systems, e.g., steams, hot water, heating, cooling systems, etc. to address LANL's higher-than-neutral pH and silica scaling problems.
 - 1. Consult the ESM Mechanical POC for specific requirements, such as type of treatment system, chemicals, etc. *For existing facilities the LANL System Engineer will be consulted to determine preferred chemicals.*
- B. Provide biocide products that are registered with the EPA, with the registration number clearly shown on the drum.
- C. Chemical supplier personnel using biocide products shall have a New Mexico Department of Agriculture (NMDA) pesticide applicator license.

⁷ Basis: ACGIH Industrial Ventilation Manual, 24th Edition, Section 5.13.5.

⁸ Per LANL Utilities Group Gas Representative, "By contract, the gas supplier must furnish natural gas with a minimum heating value of 1000 btu/ft³."

⁹ Carrier publication "Engineering Guide for Altitude Effects." (Derate 4 percent for each 1000 feet above sea level.) (EMref-9)

- D. Chemical formulations used in water treatment require RRES-WQH, Water Quality and Hydrology Group approval.¹⁰
- E. Provide an emergency eyewash per OSHA 10CFR 1910.151 and 1450 if required after an evaluation/analysis by LANL HSR-5. Consult HSR-5 Industrial Hygiene and Safety Group for additional emergency equipment requirements.
 - 1. *Guidance Note: Potable eye station may be acceptable in lieu of permanent.*
- F. Refer to the following LANL Engineering Standards:¹¹
 - 1. [Mechanical Drawing\(s\)](#) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram (future)
 - 2. Mechanical Drawing(s) ST-D30GEN-1, Open Cooling Tower Water Treatment (future).
 - 3. Construction Specification [15185](#), Chemical Water Treatment.

5.0 COILS - HEATING/COOLING

5.1 General

- A. Provide Air Conditioning and Refrigeration Institute (ARI) certified heating and cooling coils for central station HVAC units and field built-up systems.¹²
- B. For coil selection, use a manufacturer's computerized selection program to facilitate selection for the most energy efficient system, and to obtain the coil rated performance data in accordance with ARI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils, Table 1, Range of Standard Rating Conditions. <http://www.ari.org/std/standards.html>
 - 1. *Guidance: Limit dry (sensible) cooling coils to 575 fpm air face velocity.*
 - 2. *Guidance: Limit heating coils to 750 fpm air face velocity.*
 - 3. For HVAC applications, except outside air preheat coils, use a minimum tube water velocity of 2 fps.¹³
- C. Limit air velocities of wet coils (these both cool and dehumidify) to values that prevent water carryover into the ductwork.
 - 1. *Guidance: For comfort applications, wet coils are frequently selected in the range of 400-500 fpm air face velocity.*¹⁴

¹⁰ RRES-WQH is responsible for submittal of compliance data to the EPA and NMED as required for NPDES permits.

¹¹ The drawings and specification provide piping details, additional design guidance, and specifications for equipment and chemicals.

¹² ARI's Certification Directories list equipment manufacturers certified by ARI as meeting the indicated performance criteria and independently tested for compliance.

¹³ 2000 ASHRAE HVAC Systems and Equipment Handbook, Chapter 21, Air Conditioning and Dehumidifying Coils.

¹⁴ 2000 ASHRAE HVAC Systems and Equipment Handbook, Page 21.6, Performance and Ratings.

- D. Provide coils with copper tubing and aluminum fins where coil selection and design pressures permit.¹⁵
- E. Provide sloped stainless steel drip pans when installing cooling coils in built-up systems with intermediate condensate pans at each tier and interconnecting drain piping. Provide an approved P-trap at drip pan and pipe drip pans to floor drains.¹⁶
 - 1. *Guidance: For best indoor air quality choice, slope drip pans in 2 directions.*
- F. Properly size and configure condensate traps in accordance with the UMC¹⁵ and the manufacturers' recommendations.¹⁷
- G. *Guidance: Use hot water for final heating coils.*¹⁸
- H. Refer to the following LANL standard drawings for additional requirements:¹⁹
 - 1. Mechanical Drawing(s) ST-D30GEN-2, Water Coil Piping.
 - 2. Mechanical Drawing(s) ST-D30GEN-3, Steam Coil Piping.

5.2 Preheat Coils

A. General

- 1. Building air handling units shall include a preheat coil upstream of chilled water or hot water reheat coils. The preheat coil shall be sized to heat building from initial 40 degrees to 55 degrees within one hour while maintaining minimum outside airflow requirements (for buildings with automation systems, the additional capacity to provide for minimum outside air requirements is not necessary if outside air dampers will be closed during warm-up).²⁰
- 2. Operate face and bypass coils with constant steam or water flow. Do not modulate flow.
- 3. Provide a sensor in the discharge air stream to maintain a constant discharge air temperature, regardless of variations in inlet air temperature.

B. Design

- 1. Design coils for an entering air temperature of minus 10 degrees F for 100 percent outside air systems. For steam coils, oversize condensate return piping to handle large condensate flow at startup.²¹

¹⁵ Most common combination (industry standard).

¹⁶ 1997 IAPMO UMC, Section 310.

¹⁷ Trane Catalog CLCH-DC-7, Central Station Air Handlers, Application Considerations, recommended procedures for sizing condensate trap piping. (EMref 13)

¹⁸ Electric coils have a high operating cost that offsets any low initial cost. Steam coils are hard to control and require more maintenance than hot water coils.

¹⁹ The coil piping details provide piping details for different applications and additional design requirements.

²⁰ Basis: Preheat enables reasonable time for cold weather startup and restart. Buildings would not be expected to drop below 40 deg since space heaters or the like would be deployed; similarly, above 55 degrees the reheat coils would continue warmup. Lessons learned from MST Office Building.

²¹ Entering air design temperature based on lessons learned and historical climatic conditions.

2. Provide supply air preheat coils, using hot water or low pressure steam, with the necessary controls, etc., to protect them from freezing. The following are acceptable systems:
 - a. Hot water coil with circulating pump to maintain a minimum coil water velocity of 4 fps. Refer to Mechanical Standard Drawing(s), ST-D30GEN-2, Hot Water Coil – Constant Flow, Fail to Full Heat.
 - b. Vertical tube integral face and bypass steam or water coils with clamshell type dampers to control airflow.²²
 - c. Steam coil with properly designed control valve, steam trap with check valve, and vacuum breaker. Follow ASHRAE HVAC Systems and Equipment Handbook, Steam Systems.

6.0 DESIGN TEMPERATURES

6.1 Outdoor

- A. Winter: 5 degrees F dry bulb
- B. Summer: 89 degrees F dry bulb, 60 degrees F wet bulb

6.2 Indoor (Dry-Bulb)²³

- A. Cooling:
 1. General Comfort: 75 degrees F.
 2. Mechanical/Electrical Rooms: Refer to ESM Mechanical Section D30, Ventilation.
- B. Heating:
 1. Office/Laboratories: 72 degrees F (general comfort)
 2. Mechanical Rooms: 50 degrees F
 3. Storage Space (unoccupied): 55 degrees F
 4. Warehouses: 50 degrees F
 5. Kitchens: 60 degrees F
 6. Change Rooms: 75 degrees F
- C. **Note:** Program requirements may require different indoor design temperatures.

²² Integral face and bypass coils are used as a freeze protection measure. The temperature of the discharge air is controlled by proportioning entering air through the multiple heating and bypass channels of the face and bypass coils. The air is proportioned by clamshell-shaped dampers, which maintain a constant pressure drop, thus allowing a constant volume of air to pass through the unit.

²³ The heating and cooling design temperature for general comfort is within the acceptable ranges of ASHRAE Standard 55-1992, Figure 2. The remainder of the heating temperatures is based on previous designs and DOE 6430.1A, Table 1550.1.2.2.

7.0 HUMIDITY CONTROL

- A. Provide humidity control only when programmatic requirements specify humidity levels in a zone or zones (e.g., in computer or explosive areas to prevent the buildup of static electricity).
 - 1. Comply with ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy.²⁴
 - 2. Provide humidity monitoring system to automatically adjust building conditions as appropriate.²³
 - 3. *Guidance: Humidity Control is typically not practical for general comfort because of the dry climate in Los Alamos.*
- B. Provide vapor barriers in spaces requiring humidity control to prevent moisture migration and condensation in the thermal insulation.
 - 1. Humidification: Provide barrier on inside wall surfaces.
 - 2. Dehumidification: Provide barrier on outside wall surfaces.
- C. When humidity is added to a space, provide an analysis (to prevent condensation) on where dew point temperatures will occur for exterior walls, roofs, and windows.
- D. Provide humidification units with deionized water; Mechanical POC approval required for other sources.²⁵
- E. When using boiler steam for humidification, provide a steam-to-steam converter.²⁶
- F. When using a mechanical cooling system for dehumidification, install the heating coil downstream of the cooling coil to provide reheat.
 - 1. *Guidance: A preheat coil may be required to prevent freezing the chilled water coil in the winter. See Coils subsection above.*

8.0 MOTORS

8.1 Derating

- A. Pumps: Do not overload altitude-derated motors at any point on the pump curve.
- B. Fans: Do not overload altitude-derated motors beyond the design operating conditions of the fan curve.

²⁴ Provides for a thermally comfortable environment that supports the productive and healthy performance of the building occupants. Compliance meets LEED Rating System 2.0 (2 points), Indoor Environmental Quality - Thermal Comfort.

²⁵ Basis: Tapwater at LANL is high in silica and scale deposits will cause operational and maintenance issues. DI systems contain scale in vessels relatively easy to change/maintain.

²⁶ Steam boilers are chemically treated and the chemicals used for treatment are most likely not suitable for breathing air.

- C. Derate motors for continuous duty at 7500 feet altitude by 14 percent; therefore, provide motors with 16.3 percent more bhp.²⁷ Also see ESM Electrical Chapter 7, Section D5020.

NOTE: When D5020 Rev. 2 is issued (*expected late 2004*), then its requirements shall supercede this paragraph (C) and items D and E below.

- D. Do not use the motor service factor for the altitude derating or design safety margin.

- E. *Selection example (guidance):*

Pump selection: 405 gpm at 63 feet TDH, 75% efficiency

bhp = (gpm x TDH x sp gr) / (3960 x pump efficiency)²⁸

bhp = (405 x 63 x 1) / (3960 x 0.75) = 8.59 bhp

Design operating point: 8.59 bhp

Pump curve maximum load: 9.5 bhp

Motor selection for operating point:

8.59 bhp x 1.163 = 9.99 hp

Select a 10 hp motor

Check selected motor against pump curve peak:

9.5 bhp x 1.163 = 11.04 hp

Increase 10 hp selection to 15 hp

8.2 Enclosures

- A. Provide open drip-proof (ODP) motors for clean, dry indoor locations.
- B. Motors that are part of factory-assembled equipment and are located in the air stream may be either totally enclosed non-ventilated (TENV) or totally enclosed fan-cooled (TEFC).
- C. Provide TEFC motors for outdoor applications and for indoor applications in damp or dusty locations.
- D. Provide severe duty TEFC motors in wash-down locations or corrosive locations such as draw through cooling towers.
- E. In hazardous locations use explosion-proof motors that are UL labeled for the location hazard classification.

8.3 Selection

- A. For 3-Phase applications, specify "Energy Efficiency" motors with a 1.15 service factor.

²⁷ Per NEMA MG-1, 1 percent for each 300 feet above 3300 feet. For 7500 feet, derating is $(7500-3300/300) = 14$ percent. The multiplying factor is then $1/(1-0.14) = 1.163$. This adds 16.3 percent to the brake horsepower requirement.

²⁸ Cameron Hydraulic Data, Selected Formulas.

- B. For motor selection, refer to motor selection chart (Minimum Full Load Efficiency and Maximum Load) in LANL Construction Specification 16225, Induction Motors.²⁹
- C. Refer to the following LANL Engineering Standards for additional requirements:
 - 1. ESM Electrical Chapter 7 Motors.
 - 2. Construction Specification 16225, Induction Motors.

9.0 PUMPS

- A. Design and calculate the net positive suction head (NPSH) available in piping systems and ensure that the NPSH required (found on pump curve) is less than the NPSH available.
- B. Pumps shall be accessible for maintenance.
- C. Secondary pump containment (metal pan, angle iron barrier, etc.) may be required for systems handling caustic, contaminated, etc., fluids. Consult with the area HSR or RRES representative or customer for requirements.
- D. Provide a steam-powered pump when condensate must be moved to a higher elevation or great distances.³⁰
 - 1. If an electrical-powered condensate pump must be specified, provide an isolation valve between the pump and receiver to prevent draining the receiver during pump maintenance.
- E. Provide flexible couplings in the water circulating piping to prevent the transmission of sound and vibration throughout the building.
- F. Heating and cooling pumps with motors drawing 10 hp or more and serving variable flow systems shall be equipped with variable speed drives controlled by system differential pressure. *Guidance: Staged flow is not considered variable flow, VFDs not required.*³¹
- G. Refer to Mechanical Drawing(s) ST-D30GEN-4, Pump Piping Details, for additional requirements.

²⁹ ASHRAE STD 90.1 - 2001, Table 10.2.

³⁰ Steam-operated pumps provide energy savings over electrical pumps, and are used when electricity is not available or prohibited.

³¹ Basis: Pumping costs are reduced on larger systems by the addition of variable speed drives.

10.0 SYSTEM DESIGN

- A. **Primary/Secondary Systems; Unoccupied Operation:** Primary HVAC systems for office areas shall be designed to allow unoccupied shutdown and temperature setback and shall not serve rooms that require 24 hour consistent temperature control. Server rooms, telecommunications rooms, and other rooms that require 24 hour consistent temperature control shall be served by individual air conditioning systems. The Mechanical POC can grant variance from this requirement.³²
- B. **Heat Recovery:** Heat recovery systems are required for all 100% outside air HVAC systems for systems with capacity greater than 5,000 cfm except for systems carrying vapors or dust that could deposit nuclear, explosive, or other hazardous residue on the heat recovery surfaces or which can be shown to have a simple payback of greater than 10 years.
- C. **Alarm Monitoring:** Facilities with a value greater than \$1M shall be provided with a connection to the Equipment Surveillance System (ESS) or shall be provided with web-based monitoring and alarm paging. Supply air temperature, heating water temperature, space temperature or other indication of possible facility damage due to freezing shall be alarmed. Server rooms and other areas where equipment can be damaged by high temperatures shall be provided with high temperature alarms.
- D. Follow the standards for HVAC and Nuclear Air Treatment Systems (NATS) in Table D30GEN-2 which follows. They represent the minimum acceptable methods. Alternative methods including a graded approach (tailoring) may also be acceptable, but approval by the ESM Mechanical POC is required. Any implementation methods selected must be justified to ensure that an adequate level of safety commensurate with the identified hazards is achieved.

³² Basis: One of the most effective energy efficiency methods is to turn systems off. Variance appropriate example: Separate units may not be appropriate for labs requiring 24/7 ventilation.

TABLE D30GEN-2

Required Standards for HVAC and Nuclear Air Treatment Systems (NATS)				
Function/ Component	General Service (ML-3/4)	Radiological or Other Hazard Confinement (ML-3)	Safety Significant (SS/ML-2)	Safety Class (SC/ML-1)
General	N/A	DOE NACH; <i>Guidance:</i> ASHRAE DG-1; LLNL UCRL-AR-133352; DOE-STD-1132	DOE NACH; DOE G 420.1-1; DOE O 6430.1A Div 13; DOE-STD-1132 <i>Guidance:</i> ASHRAE DG-1; LLNL UCRL-AR-133352;	DOE NACH; DOE G 420.1-1; DOE O 6430.1A Div 13; DOE-STD-1132; <i>Guidance:</i> ASHRAE DG-1; LLNL UCRL-AR-133352;;
Air Flow and Controls	See ESM I&C Chapter 8			
Air Handling Units (HVAC only)	ARI 430	ARI 430	ARI 430	ARI 430
Adsorbers (NATS only)	N/A	ASME N509	ASME AG-1; N509	ASME AG-1 ; N509
Breathing Air	N/A	See ESM Radiation Protection Chapter 11		
Coils	ARI 410	ARI 410	ARI 410	ARI 410
Dampers	SMACNA; NFPA 90A; UL 555/555S; NFPA 801	SMACNA; NFPA 90A; UL 555/555S; NFPA 801	SMACNA; ASME AG-1; NFPA 90A; UL 555/555S; NFPA 801	SMACNA; ASME AG-1; NFPA 90A; UL 555/555S; NFPA 801
Fans	ASHRAE Handbooks; AMCA Standards (99, 261, etc)	ASHRAE Handbooks; AMCA Standards (99, 261, etc)	ASHRAE Handbooks; AMCA Standards (99, 261, etc)	ASHRAE Handbooks; AMCA Standards (99, 261, etc); ANS-59.2
Filtration	ASHRAE 52.2	ASHRAE 52.2	ASHRAE 52.2	ASHRAE 52.2
HEPA Filtration	N/A	DOE STD-3020; ASME N509; ASME N510	ASME-AG-1; DOE STD-3020; ASME N509; ASME N510	ASME-AG-1; DOE STD-3020; ASME N509; ASME N510
Lab Ventilation	AIHA Z9.5, NFPA 45 and 91, ASHRAE Applications Handbook Ch 13, 'Laboratories'	AIHA Z9.5, NFPA 45 and 91, ASHRAE Applications Handbook Ch 13, 'Laboratories'	AIHA Z9.5, NFPA 45 and 91, ASHRAE Applications Handbook Ch 13, 'Laboratories'	AIHA Z9.5, NFPA 45 and 91, ASHRAE Applications Handbook Ch 13, 'Laboratories'
Local Exhaust	AIHA Z9.2; ASHRAE Applications Handbook Ch 29 'Industrial Local Exhaust Systems.'	AIHA Z9.2; ASHRAE Applications Handbook Ch 29 'Industrial Local Exhaust Systems.'	AIHA Z9.2; ASHRAE Applications Handbook Ch 29 'Industrial Local Exhaust Systems.'	AIHA Z9.2; ASHRAE Applications Handbook Ch 29 'Industrial Local Exhaust Systems.'
Refrigeration Units	ARI 450	ARI 450	ARI 450	ARI 450

Titles for Table D30GEN-2

AIHA-American Industrial Hygiene Assoc

Z9.2, Fundamentals Governing the Design and Operation of Local Exhaust Systems

Z9.5, Laboratory Ventilation

AMCA-Air Movement and Control Assoc

99, Standards Handbook

261, Directory of Products Licensed to Bear the AMCA Certified Ratings Seal

ANS-American Nuclear Society

59.2, Safety Criteria for HVAC Systems Located Outside Primary Containment

ARI-Air-Conditioning and Refrigeration Institute

410, Forced-Circulation Air-Cooling and Air-Heating Coils

430, Central-Station Air-Handling Units

450, Water-Cooled Refrigerant Condensers, Remote Type

ASHRAE – Amer. Soc. of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

DG-1, “Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities.”

Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASME-Amer. Soc. Of Mechanical Engineers

AG-1, Code on Nuclear Air and Gas Treatment

N509, Nuclear Power Plant Air Cleaning Units and Components

N510, Testing of Nuclear Air Treatment Systems

DOE Directives <http://www.directives.doe.gov/>

Guide 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1 Facility Safety

NACH: Nuclear Air Cleaning Handbook, DOE-HDBK-1169

Order 6430.1A, General Design Criteria

STD 1132, Design Considerations

STD 3020, Specification for HEPA Filters used by DOE Contractors

LLNL – Lawrence Livermore Nat’l Lab

UCRL-AR-133352 Rev 1, “HVAC Systems in Nonreactor Nuclear Facilities,” 18-pp, http://www.llnl.gov/tid/lof/lof_home.shtml (largely based on DOE 6430.1A Sections 1300 and/or 1550-99.0), with 6430.1A Div 13 still being requirements for LANL at time of writing

NFPA – National Fire Protection Assoc.

90A, Installation of Air Conditioning and Ventilation Systems [use vice UMC for smoke detection and fire dampers]

91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids (National Fire Codes, vol. 4)

801, Standard for Fire Protection for Facilities Handling Radioactive Materials (National Fire Codes, vol. 11)

UL – Underwriters Laboratories

555, Safety -- Fire Dampers

555S, Safety -- Smoke Dampers

11.0 SPECIAL REQUIREMENTS FOR SAFETY-RELATED VENTILATION AND NUCLEAR AIR TREATMENT SYSTEMS (PROGRAMMATIC AND FACILITY)³³

Also see ESM Chapter 10, Hazardous Process (especially the “General” and “Effluent monitoring and Control” Sections) and Chapter 12, Nuclear.

11.1 General

- A. *Guidance: Safety-related is ML-1, ML-2, Safety Significant, and Safety Class. Generally, the safety function of ventilation and offgas systems is to provide confinement integrity and to filter exhaust, thereby preventing or mitigating uncontrolled releases of radioactive and/or hazardous materials to the environment. Ventilation and offgas systems are included as a vital part of the primary and secondary confinement design.*
- B. Provide designs for periodic maintenance, inspection, and testing of components. Include adequate shielding in the design of filters, absorbers, scrubbers, and other air treatment components to ensure that occupational exposure limits are not exceeded during maintenance and inspection activities. *Guidance: Recommended typical equipment layout details are available from the ESM Mechanical POC.*
- C. Design to facilitate decontamination and demolition, including:
 - 1. Location of exhaust filtration components of the ventilation systems at or near individual enclosures to minimize long runs of internally-contaminated ductwork.
 - 2. Equipment, including effluent decontamination equipment, which precludes to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas, including curves and turns in ductwork. Accessible, removable covers for inspection and cleanouts are encouraged.
- D. Airflow and other design requirements for specific types of ventilation systems shall comply with 29 CFR 1910, Subparts G and H. *Ventilation systems for hazardous material protection should use local exhaust ventilation (LEV) to control concentrations of hazardous materials from discrete sources, or should control the number of air changes per hour for an entire room or bay (but avoid concentration control by dilution ventilation). 29 CFR 1910, Subpart Z, provides requirements for monitoring and alarm systems for facilities that manage or use specific hazardous materials. Additional guidance on design of ventilation systems for hazardous material protection is provided in ANSI Z9.2 and ASHRAE 62.*³⁴

³³ (a) DOE G 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1 Facility Safety, Section 5.2 and (b) SRS Engineering Standards Manual WSRC-TM-95-1, Introduction Attachment 1, National Codes and Standards for Engineering/Design Tasks Matrix [required], 9/99.

³⁴ DOE G 420.1-1, Section 4.3.3; changes from 420.1-1 per D. Sassone.

- E. *Guidance: Ventilation systems are engineering controls commonly used to prevent worker exposure to hazardous materials and are used in combination with personal protective equipment and operational procedures. 29 CFR 1910, Subpart G, 1910.94, requires that where ventilation is used to control worker exposures, it must be adequate to reduce the hazardous material concentrations of air contaminants to the degree that the hazardous material no longer poses a health risk to the worker (i.e., concentrations at or below the permissible exposure limits). 29 CFR 1910, Subpart Z, 1910.1000, requires that wherever engineering controls are not sufficient to reduce exposures to such levels, they must be used to reduce exposures to the lowest practicable level and supplemented by work practice controls. The design should ensure that respirators are not required for normal operating conditions or routine maintenance activities except as a precautionary measure.*³⁵
- F. *Guidance: Ventilation systems for hazardous material protection should use exhaust hoods to control concentrations of hazardous materials from discrete sources, or should control the number of air changes per hour for an entire room or bay. Air flow and other design requirements for specific types of systems must comply with 29 CFR 1910, Subparts G and H. 29 CFR 1910, Subpart Z, provides requirements for monitoring and alarm systems for facilities that manage or use specific hazardous materials. Additional guidance on design of ventilation systems for hazardous material protection is provided in ANSI Z9.2 and ASHRAE 62. Decontamination facilities, safety showers, and eyewashes to mitigate external exposures to hazardous materials must be provided where mandated by 29 CFR 1910, Subparts H and Z. These systems must be designed in accordance with the requirements of ANSI Z358.1 and ANSI Z124.2.*³⁶
- G. *Guidance: Directed ventilation flow paths should be used to move contaminants away from worker breathing zones. The design should ensure that ventilation flow will cascade from clean areas to contaminated areas to preclude contamination spread. Uniform distribution of incoming air and/or air mixing equipment should be provided to ensure that no pockets of stagnant air exist in areas where workers are present.*³⁷
- H. *Occupied spaces should be designed to preclude locations where low oxygen content or air displacement may occur or where reactive, combustible, flammable, or explosive gas, vapor, or liquid accumulation might occur.*³⁸
- I. *The design of airborne-effluent systems should preclude holdup of particulate materials in offgas and ventilation ductwork and include provisions to continuously monitor buildup of material and material recovery. The design of systems must also preclude the accumulation of potentially flammable quantities of gases generated by radiolysis or chemical reactions within process equipment.*

11.2 Redundancy

- A. Determine the need for redundancy and the degree of redundancy in these systems required by the safety analysis process and maintenance concerns for both active and passive components.³⁹

³⁵ DOE G 420.1-1 4.3.3.

³⁶ DOE G 420.1-1 4.3.3.

³⁷ DOE G 420.1-1 4.3.4

³⁸ DOE G 420.1-1 4.3.4

11.3 Discharge Requirements

- A. Process vent streams that potentially contain concentrations of radioactive and/or hazardous materials that are greater than acceptable through an offgas cleanup system before exhausting to the environment.
 - 1. See DOE O 6430.1A, General Design Criteria, Division 13, Special Facilities, for additional requirements including Section 1326-6 for tritium gas clean-up systems (until removed from LANL Contract).
 - 2. *Guidance: Also follow the guidance contained in DOE Handbook 1132, Design Considerations.* <http://tis.eh.doe.gov/techstds/standard/>
- B. The design of safety-significant and safety-class offgas systems must be commensurate with the sources and characteristics of the radioactive and chemical components of the offgas air stream to prevent or mitigate the uncontrolled releases of radioactive and/or hazardous materials to the environment.
- C. HEPA filtering requirements are further addressed in Section D30, Subsection D3040, under the “Filters and HEPA Filter Housings” heading.

11.4 Standards

- A. *Guidance: [LIR402-830-01, Local Ventilation for Contaminant Control](#), should be reviewed for requirements potentially affecting designs for local exhaust equipment.*
- B. *For the standards that should be considered for Safety-Significant and Safety-Class Ventilation and Nuclear Air Treatment Systems (NATS) beyond those listed above or in other Mechanical sections, see Table D30GEN-2 above.*

D3020 HEATING

1.0 GENERAL

- A. The LANL Project Leader shall report to [RRES-MAQ](#), Meteorology and Air Quality Group, the planned installation, modification, or replacement of all fuel-burning equipment for determination of whether the activity or project requires regulatory permitting, emission monitoring or reporting, etc. Provide RRES-MAQ with a description of the equipment or modification; listing size, rating, manufacturer, model number, fuel, etc.⁴⁰
- B. For heating design loads, do not take credit for internal heat gains from equipment that is often de-energized, especially during off hours, e.g., lights, personal computers.⁴¹

³⁹ Safety analysis requirements/guidance documents are available at http://arania.lanl.gov/fwo_oab/html/oab_internal_links.htm

⁴⁰ LIR404-10-01, Air Quality Reviews. RRES-MAQ is responsible for reporting equipment and activities that increase air emissions to the New Mexico Environment Department (NMED). Under 20NMAC 2.72, sources may require permitting.

⁴¹ Equipment generally is not running during off-hours.

- C. Design low temperature heating hot water systems for a maximum of 180 degrees F supply temperature.⁴²
- D. Two-way valves: All heating water systems shall be designed to maximize the number of 2-way valves (versus 3-way valves) in order to reduce overall pumping power requirements. Determine minimum flow requirements from pump curve (prevent dead-heading) and provide with either 2-way minimum flow valves or 3-way valves. If a minimum flow valve is used, it shall be placed at the end of the piping run.⁴³
- E. For 100% outside air systems, use hydronic heating. Steam, electric resistance, and other methods allowed only with ESM Mechanical POC permission.⁴⁴
- F. *Guidance: When steam is available from a central plant, consider using a steam-to-hot water heat exchanger for the heating system. However, in some instances it may be cost effective to provide a gas-fired hot water boiler rather than tying into an existing steam and condensate system.*
 - 1. Provide low pressure steam supply (15 psig maximum) to the heat exchanger and preheat coil.
- G. When using TA-3 Powerhouse steam, design for incoming temperature of 500 deg F and 150 psig with ability to handle 80 psig. Civil POC may grant variance to this (*pressure is normally 100-115 psig at time of writing but may be increased to about 140 psig in the future*).⁴⁵
- H. Direct-fired furnaces/heaters are only allowed with ESM Mechanical POC permission. The POC can require air quality testing, continuous CO monitoring, or other measures.⁴⁶
- I. Mechanical rooms shall have redundant heating to prevent freeze-up in case of a boiler malfunction (e.g., electric heat or multiple boilers).
- J. Entry vestibules: Provide a source of heat to prevent freezing of water on floor and reduce cold drafts in lobbies during peak use times.
- K. Refer to the following LANL standards for additional requirements:⁴⁷
 - 1. [Mechanical Drawing](#)(s) ST-D30GEN-2, Water Coil Piping
 - 2. Mechanical Drawing(s) ST-D30GEN-3, Steam Coil Piping
 - 3. Mechanical Drawing(s) ST-D3020-1, Steam Unit Heater Piping

⁴² 1996 ASHRAE Systems Handbook, page 12.10, Low Temperature Heating Systems.

⁴³ Pumping costs for small systems are reduced by lowering flowrate.

⁴⁴ Hydronic systems are more cost effective to install and maintain than steam systems. Electric systems are expensive to operate.

⁴⁵ Email Parker to Sokoloff, 5/9/2003, and Oruch conversation with Parker notes 3/9/04. [EMref No.22] (**Note: In endnotes.**)

⁴⁶ Improper installation or maintenance can result in CO in workplace. Lessons learned, CO exposure suspected in TA-15-563 carpenter shop 11/20/03, ALO-LA-LANL-FIRINGHELAB-2003-0013.

⁴⁷ The drawings and/or specifications provide piping installation details, material specifications, and additional design requirements.

4. Mechanical Drawing(s) ST-D3020-2, Steam PRV Station
5. Mechanical Drawing(s) ST-D3020-3, Steam Drip Leg
6. Mechanical Drawing(s) ST-D3020-4, Steam Drip Pan Elbow
7. [Construction Specification](#) 15121, Steam and Condensate Specialties
8. Construction Specification 15180, Hydronic Piping
9. Construction Specification 15181, Steam and Condensate Piping
10. ESM [Civil](#) Chapter for site steam/condensate distribution system

2.0 BOILERS

2.1 General

- A. Correct boiler selection for altitude. Refer to Mechanical Chapter, Section D30GEN, Altitude Correction subsection.
- B. Provide boilers manufactured and labeled in accordance with the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boilers and Pressure Vessel Inspectors (ANSI/NB-23).⁴⁸
- C. A factory-authorized representative of the boiler manufacturer shall provide startup service, stack analysis, and training to the LANL operator. Test reports shall be furnished to LANL.⁴⁹
- D. Provide boiler water treatment. Refer to Mechanical Chapter, Section D30GEN, Chemical Water Treatment Subsection.
- E. *Guidance: Condensing boilers: Condensing boilers with peak efficiency greater than 90% and modulating burners and ducted combustion air should be used. Flue material should be stainless or other non-corrosive material and appropriate condensate drain shall be provided.*⁵⁰
- F. Provide a low NOx burner system, with a maximum NOx emission of 30 ppm, on all gas-fired boilers except where specifically waived by ESM Mechanical POC.⁵¹
 1. Refer to the above Subsection D3020, Heating Systems - General, for RRES-MAQ (Meteorology and Air Quality Group) reporting requirements.

⁴⁸ ASME B & PV Code is a LANL Work Smart Standard and NB-23 is a nationally recognized inspection code providing uniform rules.

⁴⁹ To ensure the boiler and controls have been properly installed and adjusted per the manufacturer's safety and operating requirements.

⁵⁰ Condensing boilers are generally 10% more efficient than non-condensing boilers at low loads and heating water boilers run at low loads a majority of the time. Ducting combustion air minimizes the chances of freezing mechanical room piping with un-ducted combustion air and reduces mechanical room heating costs.

⁵¹ Low NOx burners are more efficient, generate lower nitrogen oxide emissions, and may alleviate RRES-MAQ air quality permitting requirements with NMED.

- G. Provide boilers with minimum refractory.⁵²
- H. Design stacks in accordance with the boiler manufacturer's requirements, e.g., do not exceed maximum stack weight on boiler, required draft at flue outlet, etc.

2.2 Controls

- A. Provide automatically fired boilers with controls and safety devices per ASME CSD-1.⁵³
- B. Provide controls for gas-fired boilers approved and labeled by a nationally recognized testing agency.⁵⁴
- C. Water and steam boiler trim shall include, but is not limited to, the following components.⁵⁵
 - 1. Enclosed control cabinet including flame safeguard controls with a manual reset.
 - 2. Operating temperature or pressure controls.
 - 3. Water Boiler: High limit temperature control with manual reset (pipe blowdown to floor drain).
 - 4. Water Boiler: Float-operated low water cutoff with manual reset (pipe blowdown to floor drain).
 - 5. Steam Boiler: High limit pressure control with manual reset (pipe blowdown to floor drain).
 - 6. Steam Boiler: Two float operated low water cutoffs (primary and secondary) with a manual reset on the secondary.
 - 7. Pressure gauge.
 - 8. Temperature gauge.
 - 9. Safety relief or safety valve.
- D. *Guidance: If non-condensing boilers are allowed by the POC and used, hot water boiler piping may require controls, (e.g., 3-way modulating valve, circulating pump, etc.) to prevent boiler return water temperature from falling below the combustion chamber condensation temperature, typically never below 140 degrees F. Consult with boiler manufacturer for specific requirements.*

⁵² Based on previous experience from LANL's SSS boiler crew, boilers with minimum refractory require less maintenance and are cost effective.

⁵³ ASME CSD-1 is a nationally recognized standard for controls and safety devices for automatically fired boilers. The standard is intended to enhance public health and safety.

⁵⁴ 1997 IAPMO UMC, Section 1006.2.

⁵⁵ Minimum controls required by the 1997 IAPMO UMC Chapter 10, ASME CSD-1 and LANL.

- E. Where required, provide 2 or more boilers with the determination of the proportion of load each handles based on energy, redundancy, and maintenance requirements. *Guidance examples:*
 - 1. Two boilers: 40 percent and 60 percent or 50 percent and 50 percent of system load.
 - 2. Three boilers: 40 percent and 60 percent with standby at 60 percent of system load or 50, 50, 50 percent configuration.
- F. Provide controls that automatically reset hot water for building heating by building loads or by outside temperature. Refer to ASHRAE Standard 90.1, Section 6.3.4.3, for requirements.
- G. Heating water temperature reset: Whenever possible, heating water temperature reset shall be accomplished by controlling the boiler water supply temperature utilizing the burner controls rather than controlling a three-way heating water mixing valve. When using a non-condensing boiler, the lowest reset temperature shall be 140 degrees F.⁵⁶
- H. Provide an Industrial Risk Insurers (IRI) gas fuel train on gas-fired boilers greater than 400,000 Btu/hr (input rating at sea level) with pressure gauges factory installed on both sides of the main gas burner regulator.⁵⁷
 - 1. Group all gas vents and pipe one vent to atmosphere above roof to minimize roof penetrations.
 - 2. Size vent piping through roof at least one pipe size larger than the largest vent connection.
- I. On boilers with power burners, provide a temperature indicator on the boiler exit breaching.⁵⁸

2.3 Safety Relief/Safety Valves

Note: Also see Mechanical Section D20GEN, Pressure Systems Subsection

- A. For hot water heating boilers, the pressure differential between the safety relief valve set pressure and the boiler operating pressure shall be at least 10 psi, or 25 percent of the boiler operating pressure, whichever is greater. The safety relief valve shall be ASME rated at or below the maximum allowable working pressure (MAWP) of the boiler.⁵⁹
- B. For low pressure steam heating boilers, the pressure differential between the safety valve set pressure and boiler operating pressure shall be at least 5 psi, and the boiler operating pressure should not exceed 10 psi. The safety valve shall be ASME rated at or below the maximum allowable working pressure (MAWP) of the boiler.⁵⁹
- C. For high pressure steam boilers (power boilers) refer to ANSI/NB-23, Appendix F, for pressure differential between the safety valve set pressure and the boiler operating pressure.

⁵⁶ This provides boiler efficiency savings in addition to pipe heat loss energy savings. The low temperature limit of 140 degrees will prevent condensation in a non-condensing boiler.

⁵⁷ 1997 IAPMO UMC, Section 1013. IRI is the nationally recognized standard required by LANL for the gas fuel train.

⁵⁸ Required for maintenance. Stack temperatures are an effective means for monitoring boiler tube cleanliness.

⁵⁹ NB-23, National Board Inspection Code, Appendix F.

- D. Water Boilers: Pipe relief from safety relief valve, full size, to floor drain with a union or flange between the valve and discharge piping. Do not allow weight of piping to bear on relief valve.⁶⁰
- E. Steam Boilers: Pipe relief from safety valve to atmosphere above roof. Refer to Mechanical Drawing(s) ST-D3020-4, Steam Drip Pan Elbow, for additional requirements.⁶⁰

D3030 COOLING

1.0 GENERAL

- A. Design cooling systems using mechanical vapor compression equipment (direct expansion coils or chillers) when close (better than plus or minus 5 degrees F) temperature control in the space is required.⁶¹
- B. *Guidance: Consider evaporative/adiabatic cooling for areas that do not require year-round cooling and close temperature control, i.e., warehouses, shops, makeup air ventilation units, and mechanical equipment spaces.*
- C. Provide controls that automatically reset building chilled water cooling by building load or outside temperature. Refer to ASHRAE Standard 90.1, Section 6.3.4.3, for requirements.

2.0 COOLING TOWERS

2.1 Design Conditions

- A. Select cooling tower based on the following:
 - 1. Ambient wet bulb temperature (AWB), 65 degrees F.⁶²
 - 2. Tower operation at elevation per ESM Chapter 1 Section Z10 (**Note:** altitude correction required)
- B. Select the following, based on project requirements:
 - 1. Supply cold water temperature leaving cooling tower (LWT).
 - 2. Return hot water temperature entering cooling tower (EWT).
 - 3. Approach temperature (LWT-AWB).
 - 4. Range temperature (EWT-LWT).

⁶⁰ 1997 IAPMO UMC, Section 1008. The referenced mechanical drawing provides piping detail for steam safety valves and additional design criteria.

⁶¹ Based on feedback from field engineers, absorption chillers require more maintenance than mechanical vapor (refrigerant) compression chillers. Also, evaporative condensers require freeze protection and close control of water treatment (LANL water is high in silica) for a successful operation. Therefore, increased maintenance costs over the life of the equipment must be factored in when selecting absorption chillers or evaporative condensers.

⁶² AWB temperature is based on specific site conditions and previous designs.

2.2 General

- A. Provide cooling towers certified by the Cooling Tower Institute (CTI) under Standard 201.⁶³
- B. Wooden towers are not acceptable for new construction. When modifying existing towers, do not use chemically treated lumber. Steel, fiberglass, and clear untreated redwood are acceptable materials for modifications.⁶⁴
- C. Provide freeze protection for towers that operate during the winter by a suitable method such as variable speed fans, 2-speed motors, reverse fan flow during freeze-up, water return bypass in piping using a 3-way valve, immersion sump heater, etc. Refer to the drawings and specifications referenced below for additional requirements.
- D. Refer to Mechanical Chapter, Section D10-30GEN, Meters subsection, for water meter requirements in the water make-up and blow-down lines.
- E. Slope tower water horizontal return piping away from tower to prevent line from draining into tower sump when pump is not operating.
- F. Chemically treat water both in open cooling towers and the sumps of closed circuit cooling towers.
- G. Provide overflow drain piping and sump drain piping to an approved drain.
- H. Refer to latest ASHRAE HVAC Systems and Engineering Handbook (*e.g.*, 2000 edition page 36.8), for additional tower piping design for equalizing lines, isolation valves, balancing valves, etc.
- I. Refer to the following LANL Standards for additional requirements:⁶⁵
 - 1. Mechanical Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram (Future).
 - 2. Mechanical Drawing(s) ST-D30GEN-1, Open Cooling Tower Water Treatment.
 - 3. Construction Specification 15641, Steel Induced Draft Cooling Towers.
 - 4. Construction Specification 15642, Fiberglass Induced Draft Cooling Towers.

⁶³ CTI establishes standard testing and performance analysis for CTI certified independent inspectors to inspect towers to ensure manufacturers stated performance

⁶⁴ Memo from Harvey Decker, ESH-18 (RRES-WQH), dated 8/29/00, states: (EMref-5)

“As for cooling tower construction materials; several years ago the Laboratory experienced NPDES Permit exceedences for Arsenic at several older cooling towers. After investigating several possible reasons it was discovered the wood in these cooling towers was pressure treated with an Arsenic compound and this As was leeching into the water, eventually concentrating to a level that exceeded the NPDES permit for As.”

⁶⁵ The drawings and specifications provide piping details, tower and water treatment specifications, and additional design requirements.

2.3 Location

- A. Consider the cooling tower noise, drift, plume (fogging), and prevailing winds when selecting a tower site, e.g., do not locate a tower near buildings sensitive to staining or scale deposits from the tower drift or plume. Consider plume effects on adjacent roads, parking lots, etc. Locate such that the cooling tower plume cannot enter occupied spaces. Plume discharge shall be at least 5 feet above or 20 feet away from any ventilation inlet to a building.⁶⁶
- B. Provide sufficient free and unobstructed space around the unit, as recommended by the manufacturer, to ensure adequate air supply to the fans and to allow proper servicing.

3.0 REFRIGERATION SYSTEMS

3.1 General

- A. Comply with IAPMO UMC and ASHRAE Standard 15, Safety Code for Mechanical Refrigeration, including the special requirements for modern refrigerants.⁶⁷
- B. Select refrigerant types considered environmentally safe as outlined in the Clean Air Act (as amended), and the Environmental Protection Agency (EPA). The use of CFCs in new equipment is prohibited.⁶⁸
 - 1. For a list of EPA acceptable substitutes for ozone depleting substances refer to: <http://www.epa.gov/ozone/snap/lists/index.html#refac>
 - 2. Guidance: Provide systems that do not contain HCFCs.⁶⁹
- C. Provide packaged factory-assembled units where practical. Where split systems are required, provide all components (evaporator, condenser, controls, etc.) from the same manufacturer to ensure proper match and single point of contact.
 - 1. Design refrigerant lines (size, routing, traps, etc.) per ASHRAE Handbooks and manufacturer's written instructions for built-up systems to ensure proper movement of the refrigerant and the oil.
 - 2. *Guidance: Refer to Trane publication "Reciprocating Refrigeration" (or similar publication from other reputable manufacturer), for additional refrigerant line sizing criteria.*
- D. Review noise criteria when selecting compressor types. Request noise data for all eight octave band center frequencies from 63 to 8000 Hz, measured in accordance with ARI Standard 575. For additional requirements refer to Mechanical Chapter, Section D10-30GEN, Sound and Vibration Control Subsections.

⁶⁶ 1997 IAPMO UMC, Section 1131.

⁶⁷ ASHRAE Standard 15 is a recognized national standard for safe design, construction, installation, and operation of refrigerating systems.

⁶⁸ Title VI of the Clean Air Act mandates the phased out elimination of ozone depleting chemicals. Compliance meets LEED Rating System (prerequisite), Energy and Atmospheric CFC Reduction in HVAC&R Equipment.

⁶⁹ Reduces ozone depletion and supports early compliance with Montreal Protocol. HCFCs will be banned in the year 2020 per the Clean Air Act. Also, compliance will meet LEED Rating System 2.0 (1 point), Energy and Atmosphere - Ozone Depletion.

- E. Route refrigerant pressure relief valve venting to the outside of the building. Size and locate line in accordance with UMC.⁷⁰
 - 1. For low pressure refrigerants (15 psig and below) chillers, consider a rupture relief valve to replace or supplement the rupture disc (to minimize loss).
- F. Provide a factory installed and tested chiller control panel with necessary refrigeration and electrical controls for automatic safety shutdown, manual reset, pump interlocks, chiller sequencing for single and parallel chiller installations, etc.
 - 1. Unit control panel shall display chiller refrigerant and temperature data per ASHRAE Guideline 3.⁷¹
- G. Refer to LANL Construction Specification 15184, Refrigerant Piping, for additional requirements.

3.2 Air-Cooled

- A. Select air-cooled systems for operation at 95 degrees F outside air temperature entering the condenser.⁷²
- B. Provide low ambient options for refrigeration units with air-cooled condensers operating year-round and select equipment for 0 degree F minimum operating temperature.⁷²
- C. Derate air-cooled equipment for altitude. Refer to Mechanical Chapter, Section D30GEN, Altitude Correction subsection.

3.3 Water-Cooled

- A. Select the following water-cooled systems based on project requirements.
 - 1. Evaporator chilled water supply temperature leaving the evaporator.
 - 2. Condenser tower water supply temperature entering the condenser.
- B. Refer to Mechanical Standard Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram (Future), for additional requirements.⁷³

⁷⁰ 1997 IAPMO UMC, Sections 1117.8 and 1118.0.

⁷¹ ASHRAE Guideline 3, 1996, is a recognized national guideline. Refer to Section 8.1.4 for monitoring and operation of chillers.

⁷² Based on LANL site conditions and previous designs.

⁷³ The drawings provide piping details for chilled/tower water piping, including components such as chemical feeder, expansion tank, etc.

D3040 HVAC DISTRIBUTION

1.0 GENERAL

- A. Among the required NFPA National Fire Codes, the following are particularly applicable for ventilation systems.
1. NFPA 30, Flammable and Combustible Liquid Code.
 2. NFPA 45, Fire Protection for Laboratories Using Chemicals.
 3. NFPA 55, Compressed and Liquefied Gasses in Portable Cylinders.
 4. NFPA 75, Electronic Computer/Data Processing Equipment.
 5. NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
 6. NFPA 91, Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

2.0 BUILDING THERMOSTATIC ZONES⁷⁴

- A. Permanent Partitions (floor-to-ceiling): Provide the following minimum thermostatic zones:
1. Each corner office on exterior walls.
 2. Each laboratory.
 3. Each conference room.
 4. Maximum of 3 offices with similar exposure and/or internal loads.
 5. Each toilet room with a shower.
- B. Open Office Area (moveable partitions): Provide a thermostatic zone, 10-15 feet from the exterior wall, for each exposure (N, S, E, and W), and a thermostatic zone for the interior area unless Mechanical POC gives variance. Each VAV box within the zone shall serve no more than 6 supply air diffusers. *Guidance: When at least 50% of the individuals have controls a LEED credit is achieved.*

3.0 DIFFUSERS, GRILLES, REGISTERS, AND LOUVERS

- A. Select diffusers, registers, grilles, and louvers based on ASHRAE, SMACNA, and the manufacturer's recommendations. Give special attention to supply air diffusers and grilles in laboratory areas. Refer to latest ASHRAE Application Handbook chapter on laboratories (*e.g., 1999 edition Ch. 13*).
- B. Base selection on air flow, noise criterion (NC) level, air pattern, throw, mounting height, face velocity, pressure loss, aesthetic, etc., requirements.

⁷⁴ The zone requirements are based on previous experience due to building variations created by internal loads, and variations of solar load due to building orientation.

- C. Provide an integral opposed-blade damper only when a manual-balancing damper cannot be installed in the branch duct.
- D. Provide drainable blade louvers with bird-screen for outside air intake and discharge louvers to provide proper drainage of snow and rainwater.
 - 1. Louvers shall bear the AMCA Seal with ratings based on tests and procedures performed in accordance with AMCA Publication 511. The AMCA Certified Rating Seal applies to air performance and water penetration ratings.
- E. Do not use transfer grilles between areas where contaminant migration is possible.
- F. Return relief fans are required in office building air handling systems with outside air economizers (gravity/barometric building relief is not allowed without ESM Mechanical POC approval).⁷⁵

4.0 DUCTS

4.1 General

- A. Fabricate, seal, and test duct work to the applicable SMACNA standards.
- B. *Guidance: Consider the following when designing ductwork to control material and energy costs:*⁷⁶
 - 1. *Use the minimum number of fittings possible. Fittings may be expensive and the dynamic pressure loss of fittings is far greater than straight duct sections of equal centerline length.*
 - 2. *Seal ductwork to minimize air leakage.*
 - 3. *Use round duct where space and initial cost allows, as round ductwork has the lowest possible duct friction loss for a given perimeter.*
 - 4. *When using rectangular ductwork, maintain the aspect ratio as close to 1 to 1 as possible to minimize duct friction loss and initial cost.*
- C. Exit passageways, stairs, ramps, and other exits shall not be used as part of a supply, return, or exhaust air system serving other areas of the building.⁷⁷ Corridors used to convey air to and from rooms shall be approved by [LANL Fire Protection Group](#).
- D. Connect outside air ducts for building makeup air systems directly to a fan system. Do not use mechanical rooms as air plenums.⁷⁸

⁷⁵ Consensus of several Mechanical Technical Committee members concerns with FWO-DO Office Building design.

⁷⁶ SMACNA HVAC System Duct Design - 1990, pg. 2.3, Controlling Costs.

⁷⁷ NFPA 90A-1999, Section 2 - 3.11.2.

⁷⁸ A direct duct connection provides proper air distribution to the air handling unit and prevents bad odors from the mechanical room from entering the distribution system.

- E. Provide duct systems constructed of metal except for flexible connections and flexible air duct connections to equipment and diffusers.⁷⁹
- F. *Guidance: Round ducts are strongly recommended for industrial exhaust systems because they provide a more uniform air velocity to resist settling of material and an ability to withstand higher static pressure.*⁸⁰
- G. Provide flexible connections immediately adjacent to the suction and discharge ends of moving equipment, e.g., fans, AHUs, etc.
- H. Construct exhaust systems with materials suitable for service, i.e., stainless steel, non-galvanized, etc. Ducts handling high abrasive, corrosive, or radiological materials shall be smooth (welded longitudinal seam) and free from obstructions, especially at joints.⁸¹
- I. Provide minimum 18 gage material when arc welding black iron ductwork.⁸²
- J. Do not use galvanized construction for temperatures exceeding 400 degrees F.⁸²
- K. Route trunk ductwork parallel to building walls to conserve ceiling space and allow for future utilities.
- L. Minimize duct penetrations through security walls, floor, roofs, etc. Provide a security barrier when the penetration is greater than 96 square inches and more than 6 inches in its smallest dimension. Manproof using 1/2 inch diameter steel bars on 6 inch centers welded at each intersection; when issued, follow Mechanical Standard Drawing(s) ST-D3040-6.⁸³
- M. Provide an airflow indicator for new or modified fume hoods and other local exhausts such as welding bench hoods, etc. See Mechanical Standard Drawing(s) ST-D3040-1 for installation details on a hood static pressure gage.⁸⁴
- N. *Guidance: Limit duct velocities in ducts as required to help achieve design room criterion (RC) levels.*
- O. Paint visible interior duct surfaces behind air terminal units flat black as required where reflection (dark rooms), or aesthetics is a concern.

4.2 Ceiling Plenums

- A. Ceiling plenum return air systems (non-ducted) may be used when not prohibited by security, fire protection, electrical, etc., requirements.
 - 1. Provide a sound elbow to each return grille per LANL Mechanical Standard Drawing(s) ST-D3040-2.

⁷⁹ 1997 IAPMO UMC, Section 602.1.

⁸⁰ ACGIH Industrial Ventilation Manual, 24th Edition, Section 5.12.

⁸¹ Smooth ductwork will minimize material buildup, and facilitate decontamination and decommissioning activities.

⁸² ACGIH Industrial Ventilation Manual, 24th Edition, Section 5.19.1.

⁸³ [DOE M473.1-1-2002](#), pg. X-I, 2. Mesh and expanded metal not used due to air resistance.)

⁸⁴ NFPA 45 – 1996, Section 6-8.7.

2. Coordinate the use of ceiling plenum with the electrical designer for specific requirements, e.g., plenum-rated cables, etc.

B. Guidance: *Consider the following when providing a ceiling return air plenum:*

1. *Ceiling return air plenums require administration control throughout the life of the building to maintain the required fire hazard classification within the plenum. Plenums that do not meet the required classification will require fire protection sprinklers above the ceiling.*
2. *Indoor air quality issues may become a factor due to dust accumulation and rodent droppings.*
3. *With ceiling plenums, future modifications (adding additional piping and cables in the plenum) may block the air flow.*
4. *Ceiling plenums are cheaper to install and usually require less space above the ceilings.*
5. *Balancing is sometimes easier because you are only balancing one duct system, not two systems.*
6. *Open return air plenums are much easier to remodel because of lesser ductwork above ceiling system.*

4.3 Dampers

A. General

1. Provide opposed blade dampers for modulating (control) applications.⁸⁵
2. Provide manual balancing dampers at each supply and return duct branch to control the total air and facilitate balancing. Do not use splitter-type dampers.⁸⁶

B. Fire/Smoke

1. Provide a fire damper in ductwork penetrating a 2-hour or greater rated barriers. Provide an access door to service fire damper.⁸⁷ LANL Fire Protection Group shall approve preliminary and final designs.
2. Fire dampers are not required when the duct is encased in a 2-hour or greater rated enclosure.⁸⁸
3. Fire dampers may be required in nuclear exhaust systems. Consult with LANL Fire Protection Group.
4. Provide out-of-air-stream-type fire/smoke dampers where required to minimize noise generation in duct systems.
5. Provide smoke dampers where required by NFPA-101. LANL Fire Protection Group shall approve preliminary and final designs.

⁸⁵ 1990 SMACNA, HVAC System Duct Design Manual, Figure 6-4.

⁸⁶ 1990 SMACNA, HVAC System Duct Design Manual, Chapter 10, Section A(2).

⁸⁷ NFPA 90A – 1999 Section 3 –3.1.1.

⁸⁸ DOE STD 1066 – 1999, Section 14.4.2.3.

6. Refer to [ESM Fire Protection](#) Chapter for additional requirements.
7. *Guidance: Refer to SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC systems.*

4.4 Duct Lining

- A. Limit the use of duct lining as much as possible (due to potential IAQ issues). Document justification for its use. If its use is justified, limit use to the following:
 1. As an acoustical liner to absorb unwanted crosstalk, equipment, and air rush noise.
 2. To no more than 10 feet downstream of the noise-generating equipment (fan, etc.) unless Mechanical POC approval is obtained. *If additional sound reduction is required the use of manufactured sound attenuators may be required.*
 3. As an insulator when ductwork is located outdoors and requires insulation but exterior insulation (ref LCSM Section 15080) is not practical
- B. When justified, provide duct liner as specified in LANL Specification 15810, Ducts.

4.5 Duct Heat/Smoke Detectors⁸⁹

- A. Location and installation details of detectors in ductwork shall be approved by a LANL Fire Protection Group representative to ensure code compliance.
- B. Duct detectors shall:
 1. Be provided where required by NFPA 90A.
 2. Be provided where determined by a LANL Fire Protection Group representative for HEPA filter systems.
 3. Not be provided for 100 percent exhaust systems.
 4. Not be provided for 100 percent outside air intake systems.
 5. Provide photoelectric detectors. Ionization detectors are not acceptable because of less reliability at 7500 feet altitude.
 6. Refer to ESM Fire Protection Chapter for additional requirements.

5.0 EXHAUST STACKS

- A. Locate exhaust stacks to prevent the discharge air from entering into the supply systems and to permit good dispersion of air. Comply with ASHRAE Fundamentals Handbook, Airflow around Buildings and ASHRAE Application Handbook, Building Air Intake and Exhaust Design. In addition, comply to the following:
 1. Provide a minimum stack height of 10 feet above the highest point on the roof.⁹⁰

⁸⁹ Memo from J. Gourdoux to J. Corbin dated 10/31/95, and DOE STD-1066-1999, Section 14.7.2.1. (EMref-12) (*Note: In endnotes, EMref refers to an ESM team system for managing hard-to-find reference hardcopies.*)

⁹⁰ "To protect personnel on the roof." NFPA 45-2000, Paragraph A.6.4.11. ANSI/AIHA Z9.5-1992, Paragraph 4.8 also supports the 10 foot requirement.

2. Design stacks to meet project-specific wind load and seismic criteria.
 3. Comply with NFPA 780 for lightning protection and grounding requirements.
 4. Size stacks for a discharge velocity of 3000-4000 fpm. Converging outlet cones are acceptable, but not desirable. Base stack velocity calculations on the inside diameter of the stack.⁹¹
 5. For intermittently-operated systems, provide protection from rain and snow by stack drains and stack heads. Do not use a rain cap. Refer to Mechanical Standard Drawing(s) ST-D3040-3 for stack head detail.⁹²
 6. Consult with RRES-MAQ, Meteorology and Air Quality Group, for stack monitoring requirements if stack exhausts radioactive operations or other hazardous materials. NM State (NMED) permitting may be required.
- B. Refer to LANL Construction Specification 15810, Ducts, for additional requirements.⁹³

6.0 FANS

- A. Select fan construction based on system design conditions, corrosion resistance considerations, explosive/spark resistance criteria, etc.⁹⁴
- B. Provide fans that bear the Air Movement and Control Association (AMCA) Seal.⁹⁵
 1. *Guidance: Refer to AMCA Publication 302 for suggested limits for room loudness in sones.*
- C. Select fan so that its minimum operating point, such as minimum airflow for VAV systems, falls on the negatively sloping portion of the pressure curve to prevent surging or pulsation.
- D. Carefully analyze system effect in fan sizing to minimize a “derating” of the HVAC system fan. Refer to SMACNA HVAC Systems Duct Design Manual.
- E. When selecting a fan, specify, at minimum, the following:⁹⁶
 1. Airflow, cfm
 2. Total pressure at 7,500 feet elevation
 3. Total pressure at sea level (catalog value)
 4. Nameplate motor horsepower
 5. Fan wheel diameter
 6. Fan outlet velocity

⁹¹ ACGIH Industrial Ventilation Manual, 24th Edition, Section 5.16.1(3).

⁹² ACGIH Industrial Ventilation Manual, 24th Edition, Figure 5-33.

⁹³ LANL Construction Specification 15810 specifies duct materials and installation requirements.

⁹⁴ 1997 IAPMO, UMC, Section 503.

⁹⁵ The AMCA seal assures that the product line has been tested to the appropriate AMCA standards and the manufacturer’s cataloged ratings have been submitted to AMCA for approval before publication.

⁹⁶ Fan criteria will aid designer in reviewing and comparing submittals to select the fan meeting the design criteria.

7. Fan rpm
8. Rotation
9. Arrangement
10. Discharge Position (for centrifugal fans)
11. Sound rating in dBs for all eight octave band center frequencies from 63-8000 Hz and/or sone ratings.
12. Voltage, phase, HP, and calculated BHP.

7.0 FILTERS AND HEPA FILTER HOUSINGS

7.1 General

- A. Refer to latest ASHRAE HVAC Systems and Equipment Handbook chapter on Air Cleaners for Particulate Contaminants, Table 2 (*e.g.*, 2000 Edition Ch. 24), for typical filter applications.

7.2 HVAC Systems

- A. Pre-Filter: Provide a Minimum Efficiency Reporting Value (MERV) #8 filter, per ASHRAE Standard 52.2, unless usage of space dictates a higher efficiency and class of filter.⁹⁷
- B. Final Filter: Provide a MERV #11 filter per ASHRAE 52.2, if space usage dictates.

7.3 HEPA Exhaust Systems

- A. When required by codes, standards, or a LANL HSR or RRES representative, provide a high efficiency filtration system for the removal of radioactive, microbiological, carcinogenic, and other hazardous substances from exhaust air.
- B. *Guidance: The filter system (single or multiple units) may include a fire screen, pre-filter, post-filter, HEPA filters, chemical absorbers, in-place test sections, instrumentation, dampers, or other special features. Consult with a LANL HSR or RRES representative for requirements.*
- C. Final HEPA filters shall be furnished by LANL due to the DOE requirement for acceptance testing filters at a DOE filter test facility prior to use. Consult with HSR-5, Industrial Hygiene and Safety Group, for required procurement specifications.⁹⁸
 1. Temporary HEPA filters used for initial start-up and acceptance testing of the system do not require testing at a DOE filter test facility prior to use and are not furnished by LANL. Industrial grade (non-nuclear) type filter is acceptable for temporary HEPA filters.

⁹⁷ Filter class per NFPA 90A - 1999, Section 2-2.2.2. Providing a minimum 30% efficient filter requires less filter replacement based on previously documented maintenance records from David A. McIntosh, FWO-SEM (presently FWO-MSE).

⁹⁸ DOE-STD 3022-1997, Section 4.0.

2. For new projects, final HEPA filters are supplied and installed by the project.
3. For HEPA filter replacement, the FMU supplies and installs the filters.
- D. Test (in-place) final and replaced HEPA filters in accordance with LIR 402-830-01. HSR-5, Industrial Hygiene and Safety Group, will provide in-place testing service when requested. Temporary HEPA filters installed for initial start-up and acceptance testing of the system during the construction phase does not require testing.
- E. Refer to the following LANL standards for additional requirements:⁹⁹
 1. Mechanical Drawing(s) ST-D3040-4, HEPA Filter Plenum
 2. Mechanical Drawing ST-D3040-5, Air Filter Differential Pressure Gauge
 3. Construction Specification 15865, HEPA Filters
 4. Construction Specification 15885, HEPA Filtration
- F. *Guidance: Typical layouts for HEPA filter plenums that allow adequate maintenance space are available from the ESM Chapter 6 POC.*

8.0 INTAKES

- A. Locate intakes at least 24 inches above grade to prevent intake of snow.
- B. For systems on large or high visibility buildings that are not within secure areas, locate HVAC air intakes at least 10 feet above grade (lower allowed with Mechanical POC approval).¹⁰⁰

9.0 PRESSURIZING SPACES/BUILDING

- A. Maintain office spaces under a positive pressure to prevent outside air infiltration and/or infiltration from laboratory spaces that adversely impact air quality.¹⁰¹
- B. Maintain laboratory spaces under a negative pressure, minus 0.03 to minus 0.15 inches of water, in relation to non-laboratory spaces (offices, corridors, etc. and/or the outside environment).¹⁰²

⁹⁹ Standard drawings and specifications provide required instrumentation details, HEPA filter plenum details, and specification and installation requirements for filters and housings.

¹⁰⁰ Protect against contaminants like pesticides, chem/bio/rad; ASHRAE Report of Presidential Ad Hoc Committee for Building Health and Safety under Extraordinary Incidents on Risk Management Guidance for Health, Safety and Environmental Security under Extraordinary Incidents 26 January 2003.

http://www.ashrae.org/content/ASHRAE/ASHRAE/ArticleAltFormat/2003716113740_347.pdf

¹⁰¹ IAQ issue. Meets LEED Rating System 2.0 (1 point), Indoor Environmental Quality - Indoor Chemical and Pollutant Source Control.

¹⁰² Negative pressure values based on 1999 ASHRAE Applications Handbook, Chapter 25, Nuclear Facilities, page 25.5, guidance for "Secondary Containment."

10.0 VARIABLE AIR VOLUME (VAV) BOXES

- A. Provide pressure independent VAV boxes, Air Conditioning and Refrigeration Institute (ARI) certified, and completely factory assembled.¹⁰³
- B. The minimum supply air setpoint at the VAV box shall not be less than the required minimum ventilation requirements of ASHRAE Standard 62.
- C. Provide a factory-mounted safety switch disconnect with thermal overload protection when selecting a 120V/277V terminal unit.¹⁰⁴
- D. *Guidance: Use static regain duct design method for high velocity variable air volume systems.*¹⁰⁵

11.0 VENTILATION

- A. Provide ventilation to spaces that people may occupy in accordance with ASHRAE Standard 62, except where other applicable standards and requirements dictate larger amounts of ventilation.¹⁰⁶
 - 1. If it is stated in Project Documents or is suspected by the designer that the outdoor air is influenced by sources that cause substantial contamination, evaluation for acceptability is required.
 - 2. *Avoid locating outside air intakes close to heavy vehicle traffic areas such as loading docks, near diesel generators, or near equipment that can produce objectionable odors or sprays, such as trash dumpsters, cooling towers, etc.*
- B. Design with the assumption that smoking will be prohibited.¹⁰⁷
- C. *Guidance: Design the HVAC system with carbon dioxide (CO₂) monitoring sensors and integrate these sensors with the building automation system. Locate sensors in locations most likely to contain high levels (e.g., conference rooms) and as required to meet ASHRAE 62. Specify internal operational setpoint parameters that maintain indoor carbon dioxide levels no higher than outdoor levels by more than 530 parts per million at any time.*¹⁰⁸

¹⁰³ In pressure independent VAV boxes, the design air flow does not fluctuate due to a change in duct pressure. ARI certification assures that the product has been tested to appropriate ARI standards and the performance ratings are as specified in catalog data.

¹⁰⁴ 1997 IAPMO UMC, Section 309.

¹⁰⁵ 1990 SMACNA, HVAC System Duct Design Manual, 3rd Edition, page 4.3, Static Regain.

¹⁰⁶ LANL WSS. Complying with ASHRAE STD 62 meets LEED Rating System 2.0 (prerequisite), Indoor Environmental Quality - Minimum IAQ Performance.

¹⁰⁷ Practically banned by [Executive Order 13058](#), and to lesser extent by [LANL Administration Policy AM 626](#). Total ban meets LEED Rating System 2.0 (prerequisite), Indoor Environmental Quality - Environmental Tobacco Smoke Control.

¹⁰⁸ CO₂ monitoring sustains long-term occupant health and comfort. Compliance will meet LEED Rating System 2.0 (prerequisite), Indoor Environmental Quality - Carbon Dioxide Monitoring.. Location note lessons *learned*, C-Div Office Bldg.

- D. Provide a mechanically-operated ventilation system for toilet rooms, janitor closets, and other malodorous spaces, connected directly to the outside. Point of discharge shall be at least 10 feet from any opening that allows entry into the occupied portions of the building.¹⁰⁹
 - 1. Exhaust at a rate of not less than 2 cfm per square foot or as specified in ASHRAE Standard 62, using greater airflow rate.
- E. Equipment Room: Exhaust mechanical and electrical equipment rooms so that the room temperature does not exceed 95 degrees F. Where mechanical ventilation cannot maintain a satisfactory environment, provide mechanical cooling.
 - 1. Refer to the LANL Engineering Standards Manual, Electrical Chapter, for ventilation and/or cooling requirements for transformers, UPS systems, battery areas, telecommunication rooms, etc.
 - 2. Ventilate equipment rooms containing refrigeration equipment in accordance with ASHRAE Standard 15 including refrigerant leak alarms where required.
 - 3. Provide combustion air for fuel-burning equipment in accordance with the UMC.
- F. *Biological/chemical/radiation airborne attack prevention: Guidance: The following NIOSH documents are available:*
 - 1. [Guidance For Filtration And Air-Cleaning Systems To Protect Building Environments From Airborne Chemical, Biological, Or Radiological Attacks, CDC/NIOSH 2003-136](#)
 - 2. [Guidance For Protecting Building Environments From Airborne Chemical, Biological, Or Radiological Attacks, CDC/NIOSH 2002-139.](#)

¹⁰⁹ 1997 ICBO UBC, Section 1202.2.1 allows 3 feet clearance. LANL has increased clearance to 10 feet based on previous problems.

D3060 INSTRUMENTATION AND CONTROL (I&C)

- A. Follow [ESM Chapter 8, I&C](#), where the majority of requirements are given. Boiler controls are addressed in Section D3020 above.

D3070 TESTING, ADJUSTING, AND BALANCING (TAB)

- A. Provide TAB for new HVAC and industrial exhaust equipment/systems in permanent buildings and temporary buildings (i.e., trailers and transportables) with laboratories.
1. *Guidance: TAB should be repeated for modified system and those systems affected by the modification. TAB may also be required for temporary buildings when requested by the building owner.*
- B. The TAB Agency performing the work shall be certified by either the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).¹¹⁰
1. The TAB Agency shall be independent of any HVAC contractor performing the work (i.e., Mechanical or Controls), and shall be a direct sub to LANL (not Contractor retained).
 2. *Guidance: Contact BUS-5, 667-5244, Procurement Group, to utilize existing contract with a certified TAB agency.*
 3. *Guidance: The TAB Agency certification may be verified at <http://www.aabchq.com/index.htm/> or <http://www.nebb.org/tab-man.htm/>*
- C. Provide permanent means for balancing the air and water systems. *Guidance: Devices can include, but are not limited to dampers, flow measuring stations, temperature and pressure test connections, gauges, balancing valves and flow sensors.*
1. Install devices (pressure gauges, thermometers, etc.) on major equipment, e.g., water chillers, cooling towers, pumps, coils, heat exchangers, etc.
- D. Refer to LANL Construction Specification 15950, Testing, Adjusting, and Balancing for additional requirements.¹¹¹

¹¹⁰ ASHRAE Standard 90.1-2001, Section 6.2.5.3 requires HVAC systems to be balanced in accordance with generally accepted engineering standards. NEBB and AABC are nationally recognized organizations that maintain uniform standards for the testing, adjusting, and balancing of environmental systems.

¹¹¹ LANL Construction Specification 15950 specifies the requirements of the TAB contractor and the scope of work to be performed.